Solar Flair

Celebrating 20 Years of Sustainable Design Excellence

Penn State Solar Decathlon 2022

Design Challenge – Retrofit Housing

Penn State's MorningStar House

MorningStar at the National Mall

MorningStar at the Sustainability Experience Center

2002 — First Solar Decathlon Build Challenge

2007 — MorningStar designed by Penn State's Solar Decathlon Team for 2007 Build Challenge

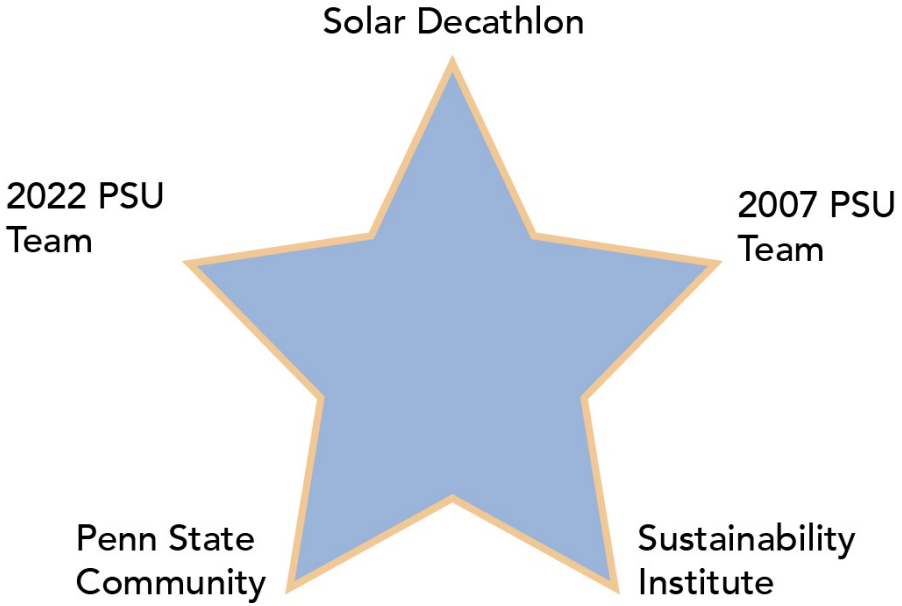
2009 — House is settled into Sustainability Experience Center

2009 - 2022 — PV Panels recalled, outdated mechanical and energy systems

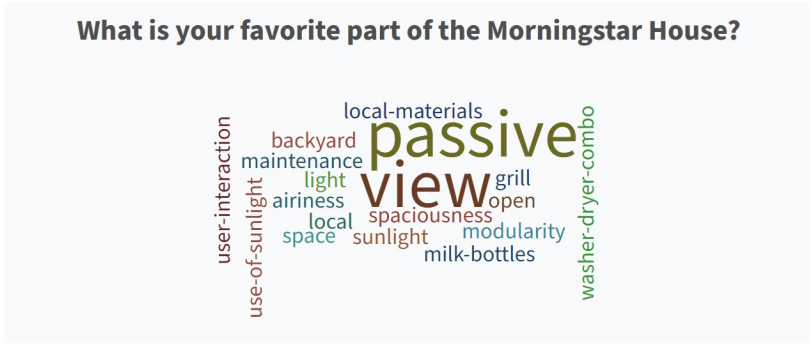
2022 — Sustainability Institute asks 2022 Design Team to retrofit the house

Stakeholders

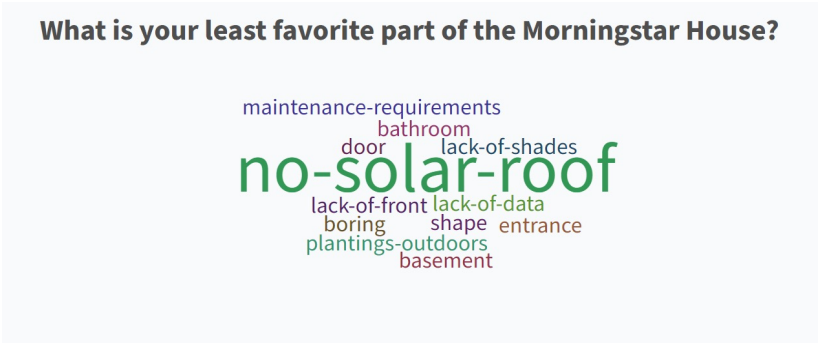
Site visit of the house with the Sustainability Institute



Stakeholders involved with the MorningStar House



Feedback from the Sustainability Institute



Feedback session with the original team leaders for the MorningStar House in the 2007 Build Challenge

Click to add text

Interview with 2007 Leader
Oct. 18th

Nov. 1st
Interview with 2007 Leader

Meeting with Sustainability Institute
Nov. 8th

Nov. 15th
Interview with 2007 Leader

Meeting with Sustainability Institute
Dec. 6th

Feb. 9th
Presentation to 2007 Leaders

Presentation to Sustainability Institute
Feb. 16th

March 30th
Presentation to 2007 Leaders

Presentation to Sustainability Institute
April 13th

Fall Semester

Spring Semester

Retrofit Concepts

- Honoring History and Legacy
- Staying on the Cutting Edge of Technology
- Settling into Existing Site

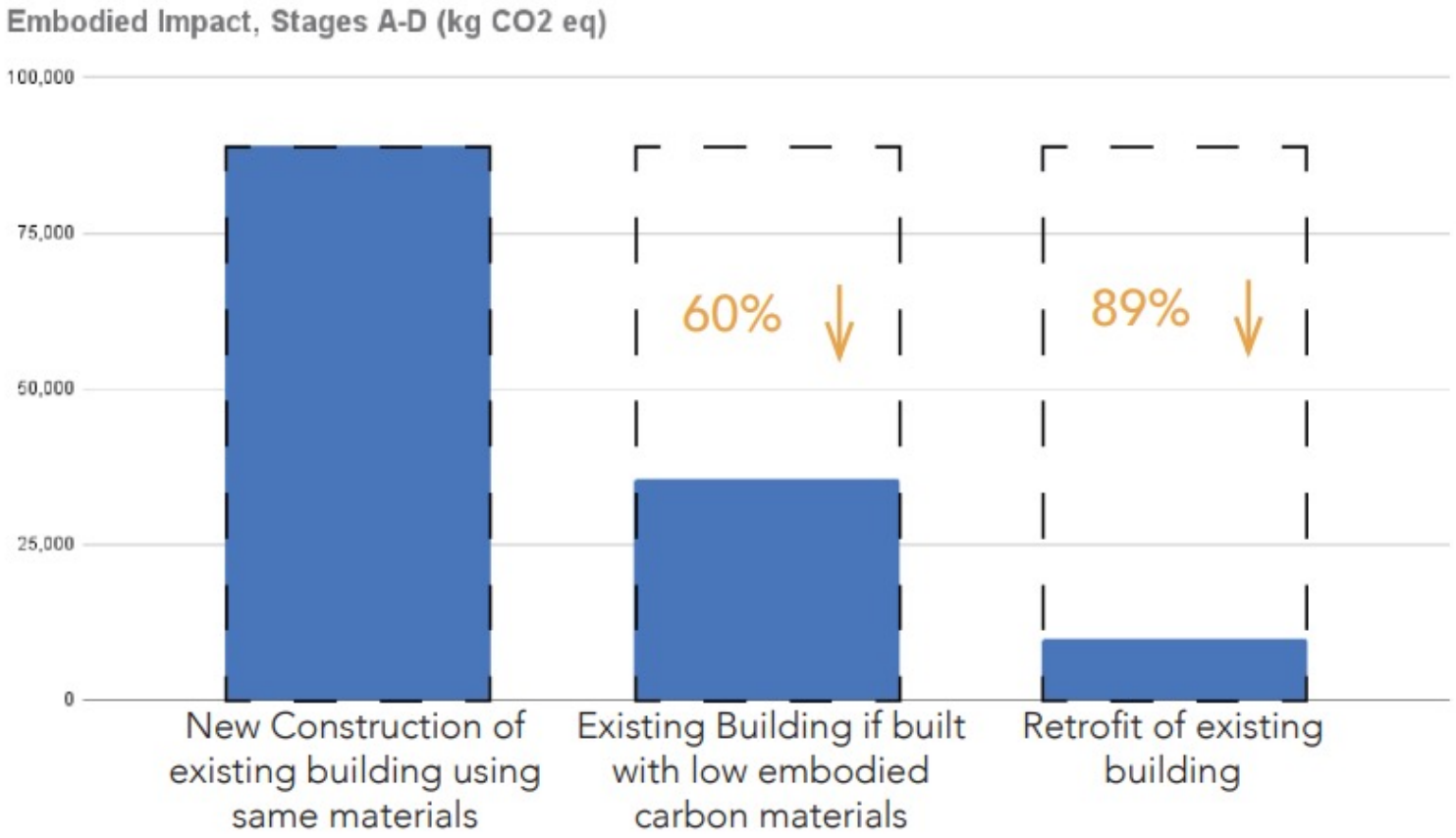
Design Goals

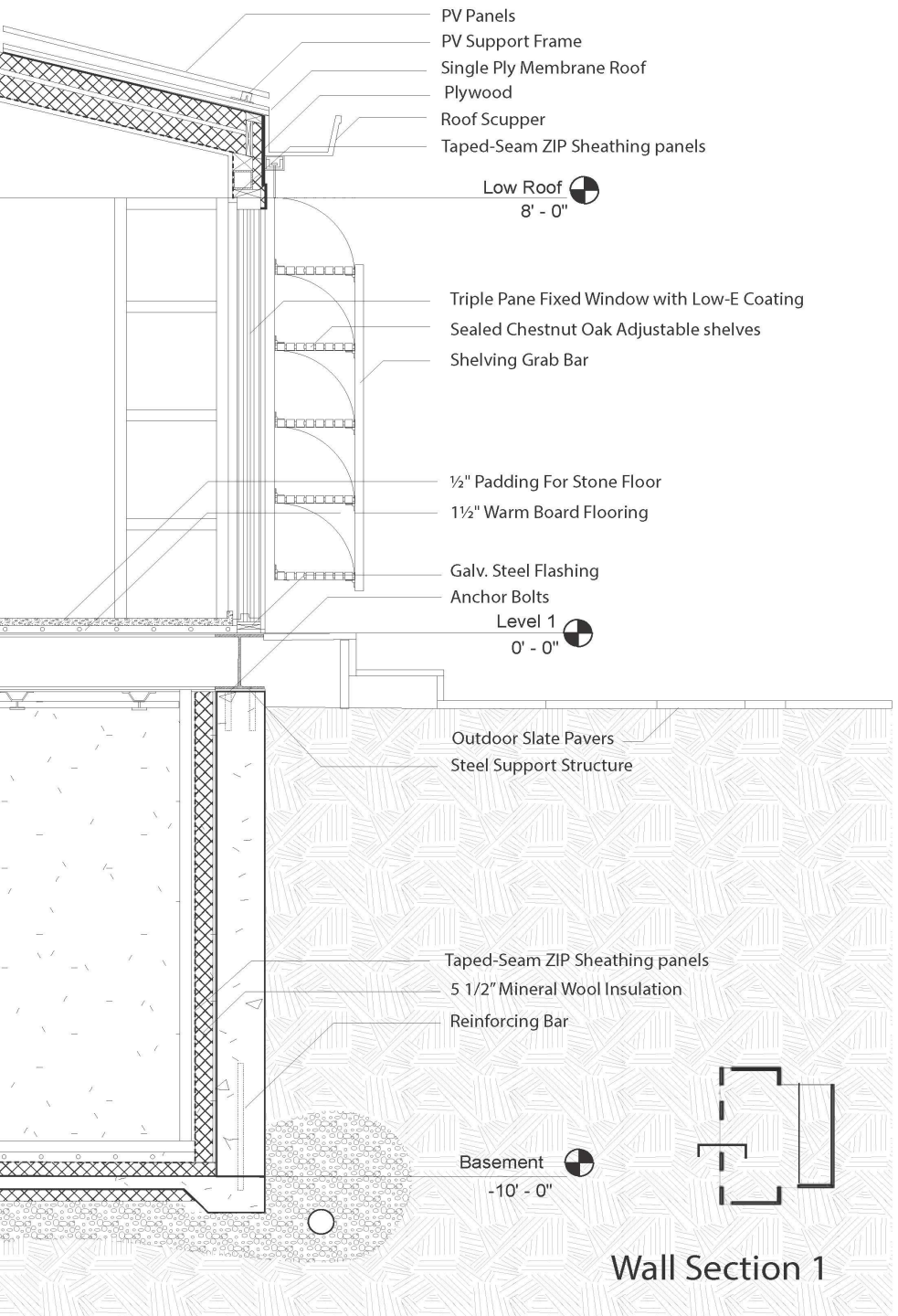
- Site and Building Performance
- Materials and Waste
- User Experience

Why Retrofit?

- A retrofit has **89%** less global warming potential of a new construction for the same purpose

Teaching sustainable design principles → Teaching sustainable retrofit principles



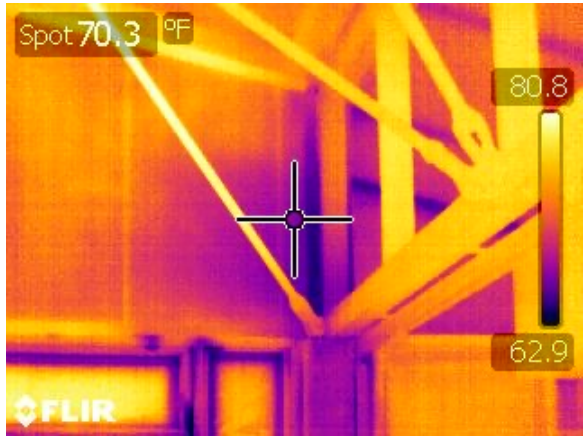


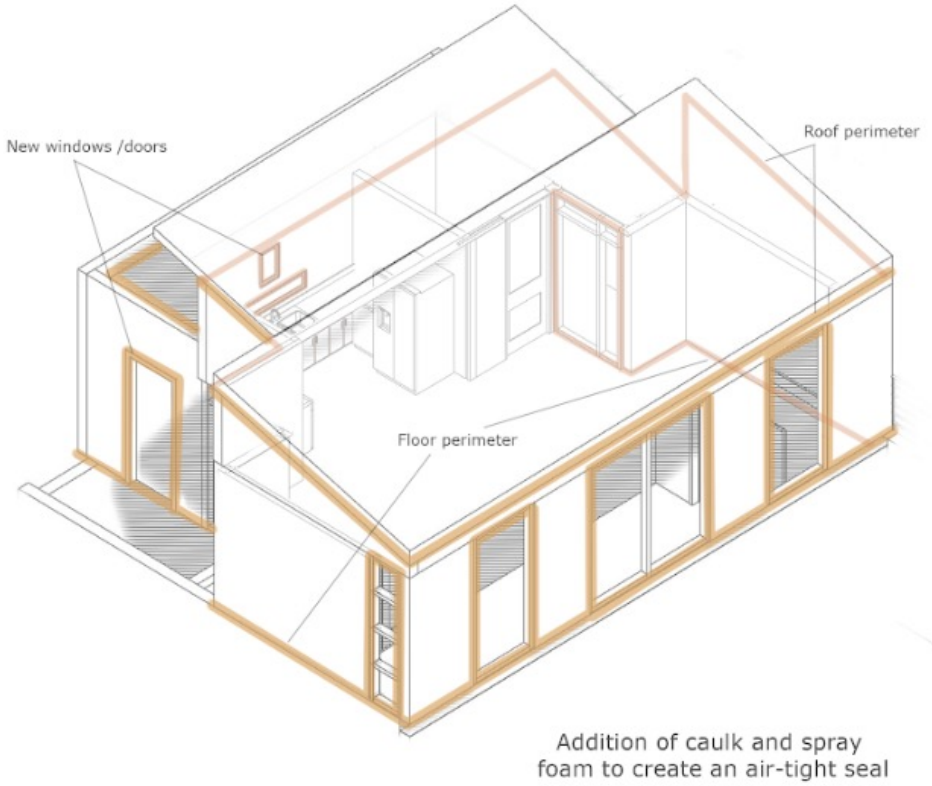
Wall Section 1

Architecture | Engineering | Durability & Resilience | Embodied Environmental Impact | Integrated Performance | Occupant Experience | Comfort & Environmental Quality | Energy Performance | Presentation

Envelope – South Facade

Envelope – Air Sealing

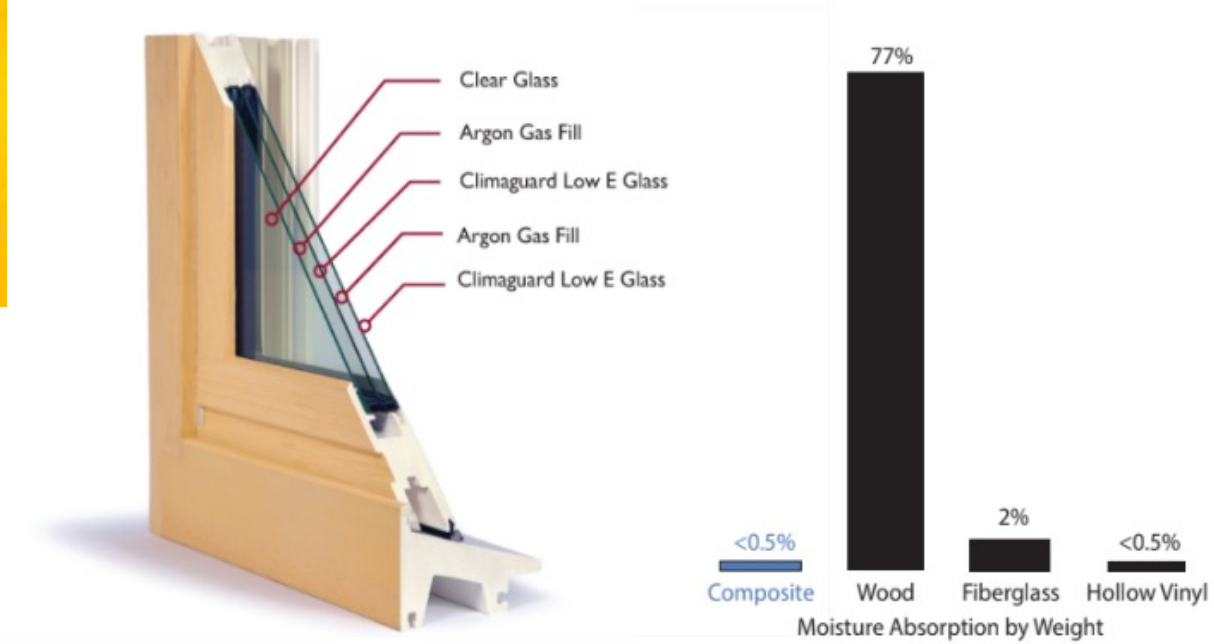




Addition of caulk and spray foam to create an air-tight seal

Envelope – Windows/Doors

Architecture | Engineering | Durability & Resilience | Integrated Performance | Comfort & Environmental Quality | Energy Performance | Presentation



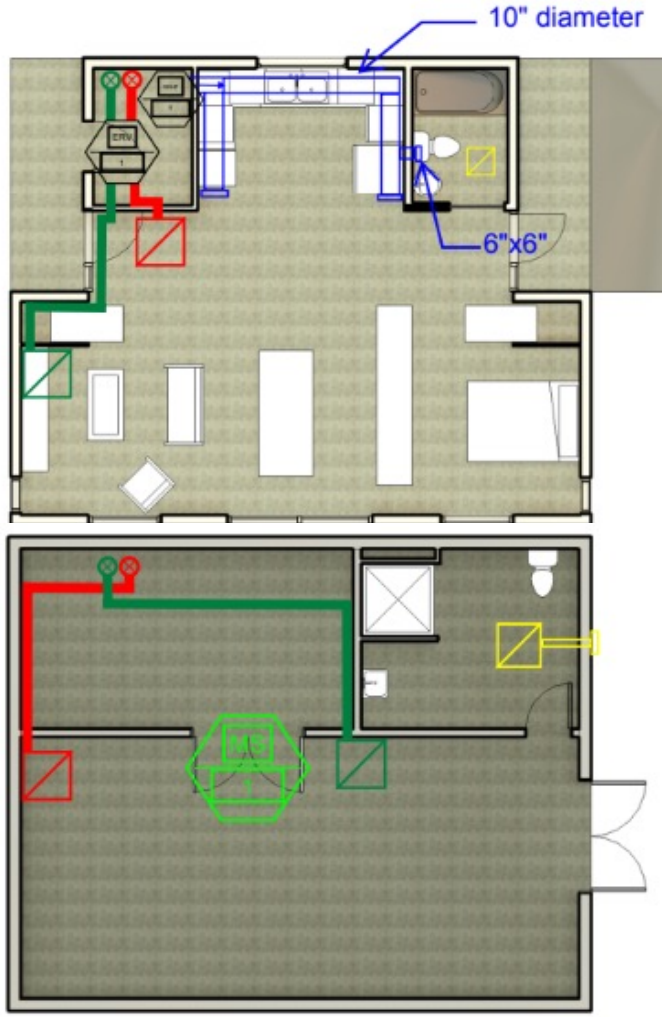
Mechanical Upgrades

Rheem ProTerra

- 3.75 EF
- 40 Gallon Capacity

Zehnder ComfoAir 550

- 324 CFM
- 95% efficiency
- 10-350W Power



Energy Demand

Air Leakage ↓

Architecture
Engineering
Durability & Resilience
Embodied Environmental Impact
Integrated Performance
Comfort & Environmental Quality
Energy Performance
Presentation

Energy Demand

Architecture | Engineering | Durability & Resilience | Embodied Environmental Impact | Integrated Performance | Comfort & Environmental Quality | Energy Performance | Presentation

Air Leakage ↓

=

Site EUI: 22.03 reduced to 13.95

Energy Production and Storage

47 kWh battery

2.5 kW **increased to** 11 kW total solar

Solar Production (kWh)

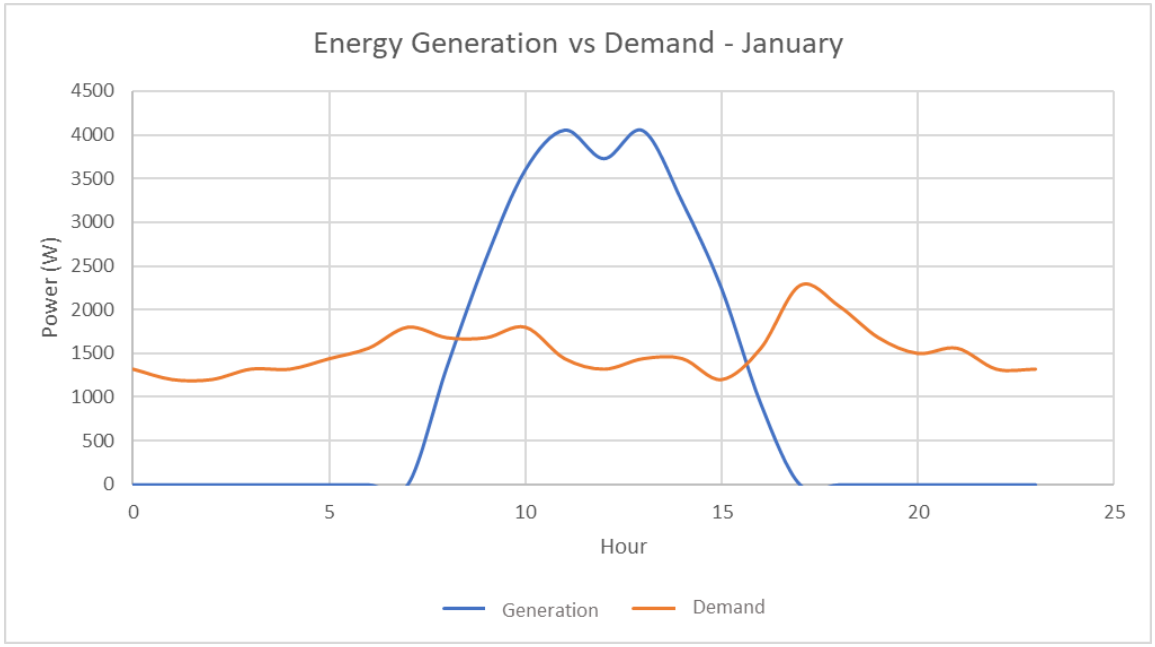
Month	
Jan	789
Feb	872
Mar	1,157
Apr	1,253
May	1,427
Jun	1,400
Jul	1,513
Aug	1,400
Sep	1,238
Oct	988
Nov	749
Dec	620

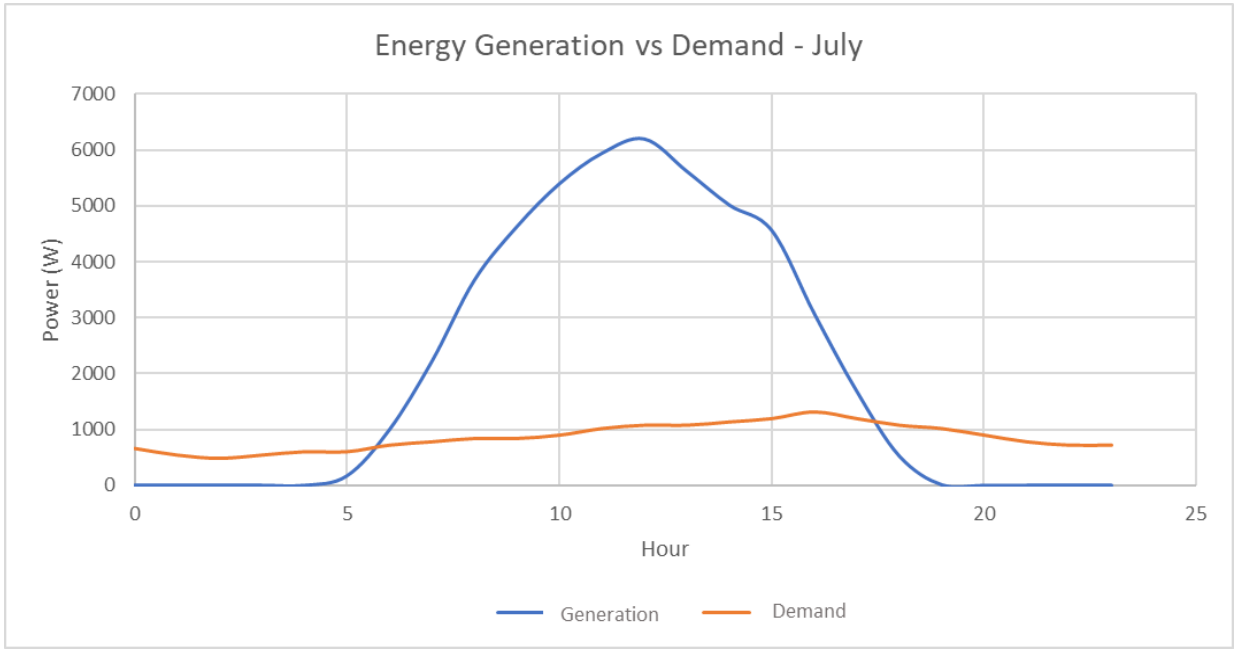
Corresponding Value ($)

Month	
Jan	59
Feb	65
Mar	86
Apr	93
May	106
Jun	104
Jul	113
Aug	104
Sep	92
Oct	74
Nov	56
Dec	46

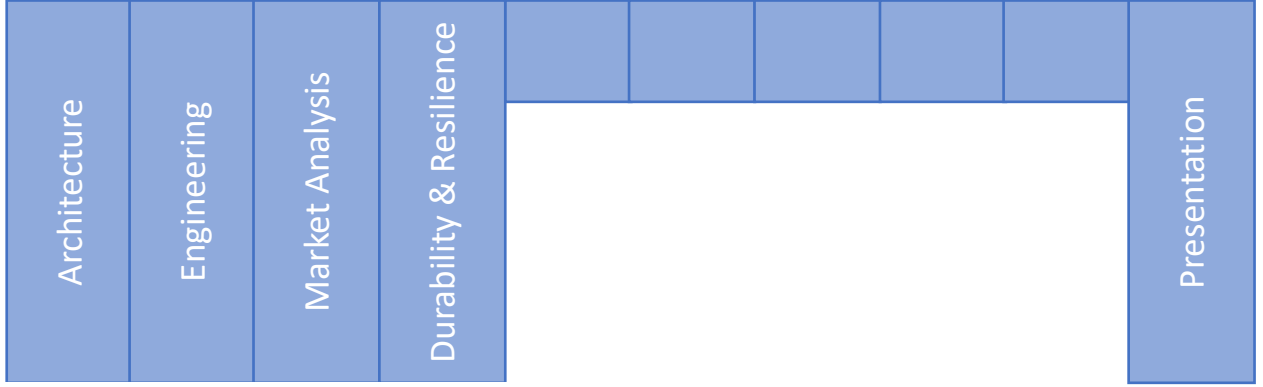
3 MWh **increased to** 13.4MWh estimated annual production with just over 7 MWh energy demand

Energy Production and Demand





Market Analysis

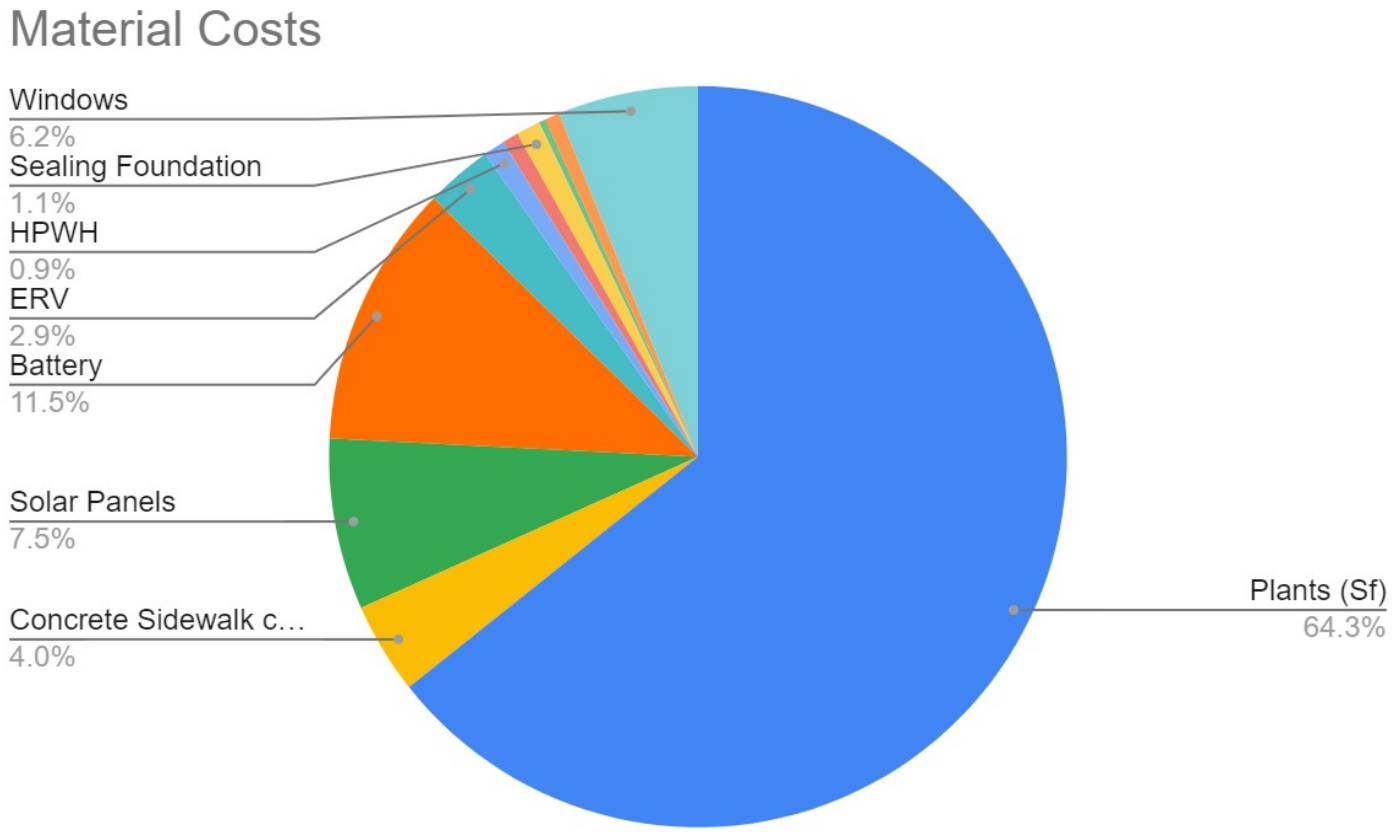


Tier 1:

- Air sealing
- Insulation
- ERV
- Solar Panels
- Battery
- Windows & Doors
- Handicap-Accessible Sidewalk

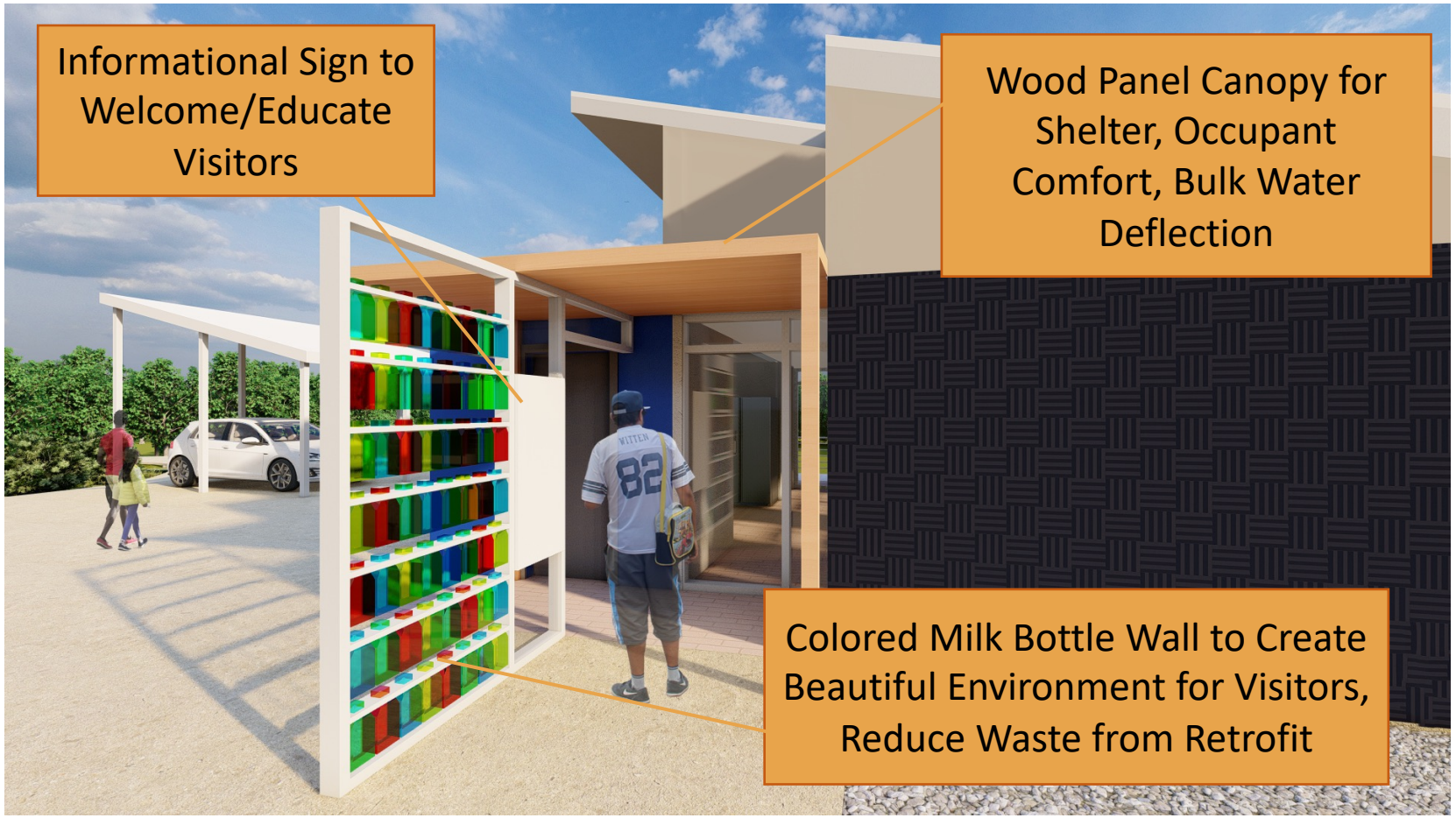
Tier 2:

- No-mow lawn
- Swale & Raingarden
- Pollinator Garden
- Meadow & Sculpture Garden
- Audubon Garden
- Orchard



Total Cost of Retrofit: $170,640

Architecture Updates Exterior



Architecture Updates
Exterior

Architecture Updates Interior

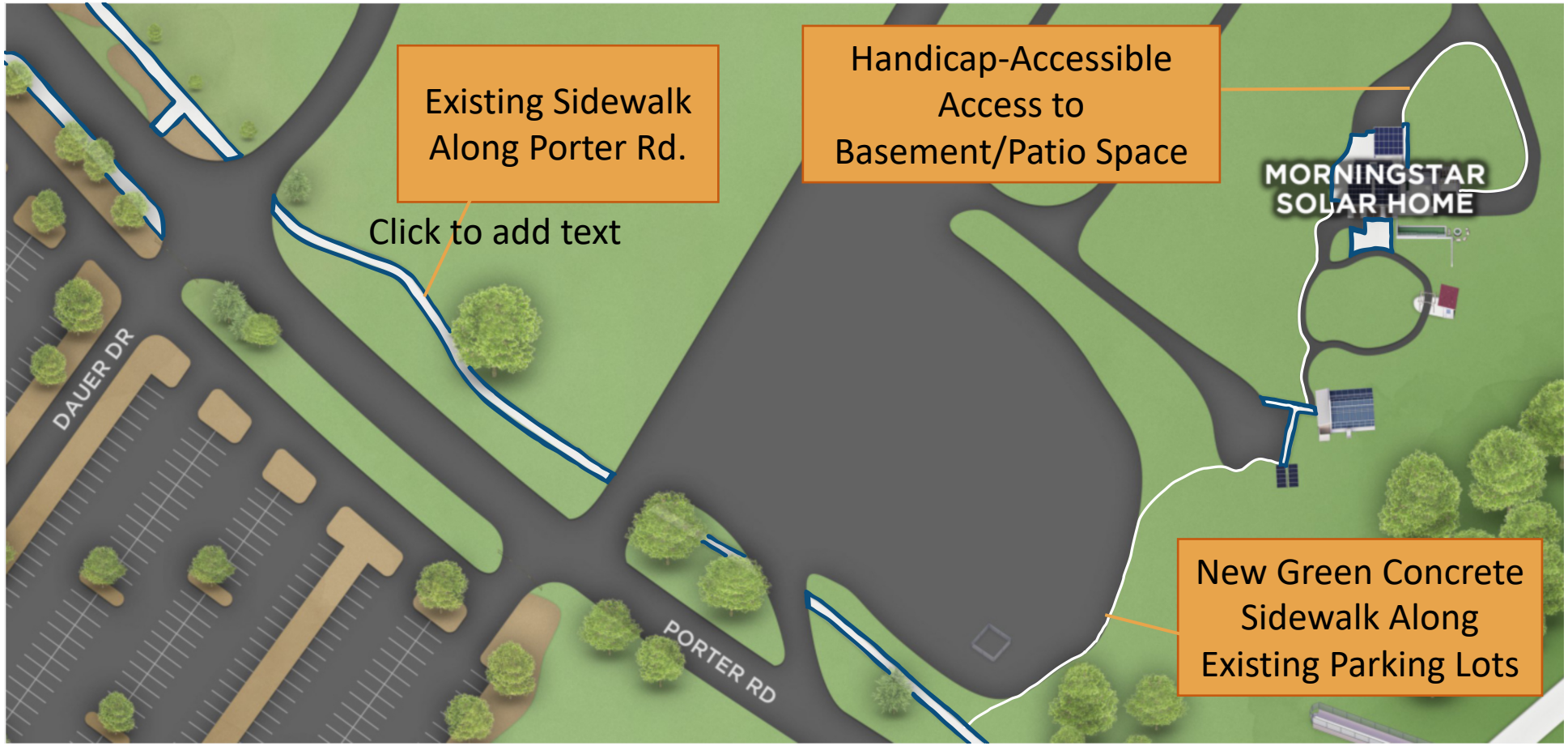
Architecture | Engineering | Durability & Resilience | Embodied Environmental Impact | Integrated Performance | Occupant Experience | Comfort & Environmental Quality | Energy Performance | Presentation

Architecture - Basement

Architecture	Engineering	Market Analysis	Durability & Resilience	Embodied Environmental Impact	Integrated Performance	Occupant Experience	Comfort & Environmental Quality	Energy Performance	Presentation

Architecture - Pathing

- Intentional direction and flow through site
- Handicap-accessible for everyone to enjoy
- Community connections



Architecture - Landscaping

Celebrating 20 Years of Sustainable Design Excellence